CHAPTER 4: Components of a Boiler Part 2

Pressure Switches

These devices control steam pressure and start or stop the burner. They are connected in the same way as the boiler's pressure gauges and consist of a pressure-sensitive element (a special bronze or stainless steel bellows, compressed by springs with adjustable force via nuts and bolts; a system of levers actuates electrical contacts).

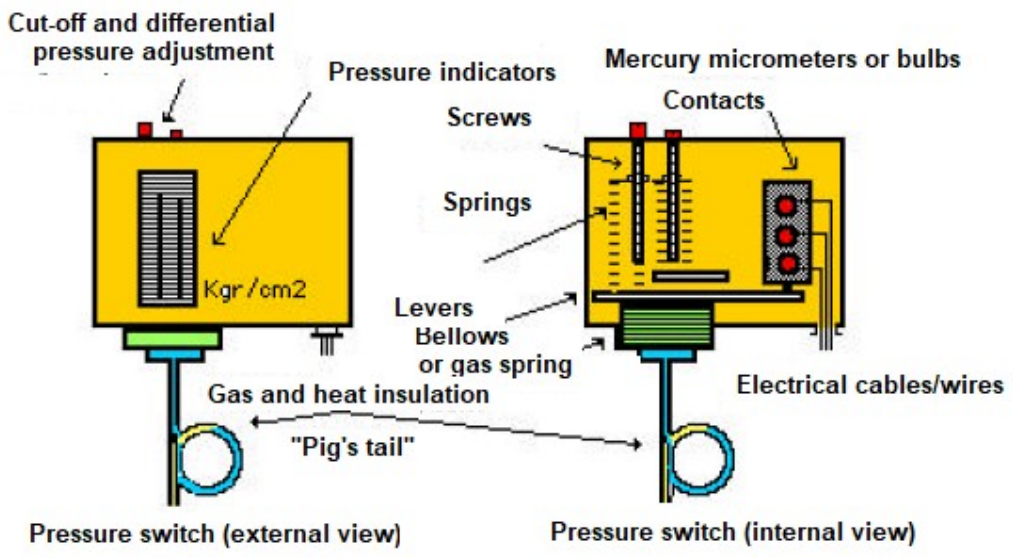
The actuation of this element on contacts can be adjusted so that a contact can "open" at a specific pressure (high-pressure cutoff) and "close" at a lower pressure (burner start-up).

The difference between the high pressure (cutoff) and the lower pressure (start-up) is adjustable (called the "differential"), allowing a boiler to start at a specific pressure and shut down at a higher one.

These elements must be connected without valves and by means of gas and steam temperature insulators ("pigtails", chambers or "U-tubes") to prevent corrosion and weakening of the bellows (due to temperature).

These pressure switches must be adjusted to operate at the desired cutoff (turn-off) or start-up (turn-on) pressures. To do this**, the cutoff pressure (normally) must be adjusted first, and then the start-up pressure (start-up) is adjusted by turning on the differential screw.**

Never create an electrical "bridge" to eliminate a pressure switch, as the only thing that can limit the pressure will be the safety valves.



Do not install valves between the pressure switches and the boiler.

Clean the connections once a year: disassemble, blow through with air and water, and use a cleaning cloth if necessary. There should be no steam or water leaks when reassembled.

To observe the operation and the start ("connect") or cut-off ("disconnect") pressure values, check the pressure on the boiler's pressure gauge in each case, as the settings for these pressure switches are approximate (not exact).

In wood-burning boilers, pressure switches operate the forced air and induced draft systems to control the air and combustion gases (to "shut down" combustion, the air inlets are turned off or closed—turning off or closing the forced air and induced draft systems).

This creates a lack of oxygen for continued combustion, which is restored when air is allowed to enter again as the wood remains incandescent among the ashes (coal).

There are pressure switches (modulating) that, instead of contacts, have a variable electrical resistance, allowing them to control a "modulating" motor (which, instead of turning on and off, moves slowly from "closed" to fully "open" and stops at the set pressure point). In this way, we can control a burner continuously (whether wood, oil, or gas): this is the ideal control method.

Boilers may have more than one pressure switch, as there can be an "extra" overpressure switch.

Which, in case of failure of the first one, cuts off at a higher pressure, shutting off the burner, triggering an alarm, and requiring manual reset.

The manual reset is very important, as it alerts the boiler operator that the high-pressure cutoff switch is failing.

The operator will have to perform the manual reset, and it is advisable to replace the high-pressure cutoff switch, as it will fail again, provided there was no other cause for the very high pressure, but before the safety valves activate.

For safety, there may be two pressure switches: one for start and stop, and a second pressure switch to operate the burner with a "high" flame (semi-modulated, with two flames: low and high) or with full modulation.

A third pressure switch for a third flame (semi-modulation, 3 flames: low, medium, and high, aiming for continuous modulation).

The ideal operating condition of a boiler is to maintain the pressure as close as possible to the desired operating pressure and for the burner to remain lit, adjusting to the needs of maintaining that pressure (which will vary according to steam consumption; this is called continuous modulation, and it makes the boiler more economical or efficient than if the burner were to cycle on and off).

Fusible Plugs

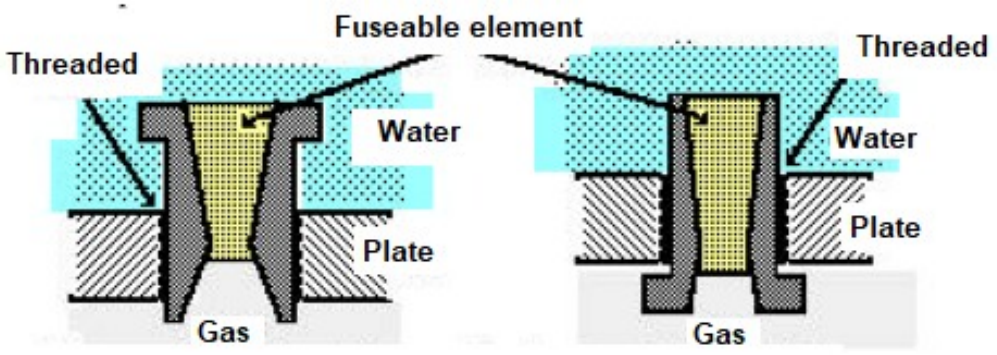
Fusible plugs (which melt when heated) are required as standard practice in low-pressure boilers (generally fire-tube boilers).

These plugs are shaped like a cap (made of copper alloy) with a threaded connection and a central hole filled with a material that melts at a specific temperature (generally pure tin, which melts at around 230°C, although special alloys may be used in some cases).

These fusible plugs are screwed onto areas (plates or sleeves) below the water level in the boiler. These areas will superheat as the water level drops, melting the center of the plug and allowing the steam pressure to escape (inside the flue gas passage or, in some cases, to the outside).

They must be replaced whenever they leak, melt, undergo chemical cleaning, or twice a year as a routine maintenance.

Do not attempt to refill a melted plug yourself or replace it with a blanking plug: **replacement plugs must always be original (supplied by the boiler manufacturer).**



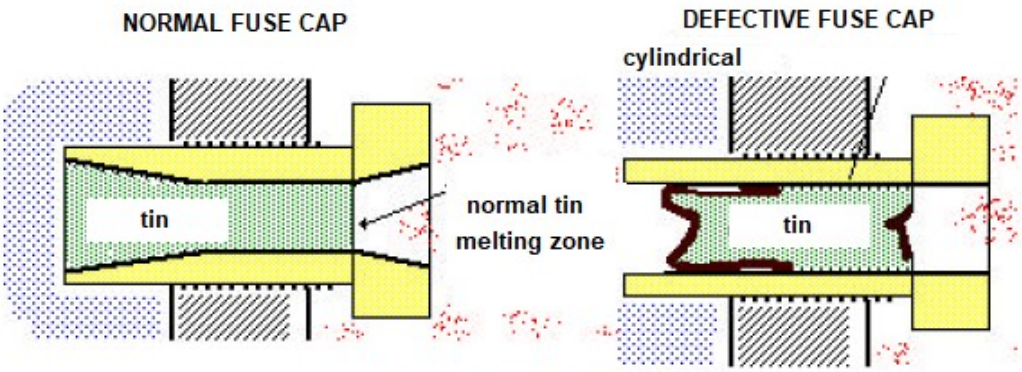
Fuse Plugs: Water side threaded - Gas side threaded

If you encounter a boiler with a melted fusible plug, a thorough inspection should be carried out to check for overheating (tube leaks, misaligned plates, deformed combustion chambers, etc.).

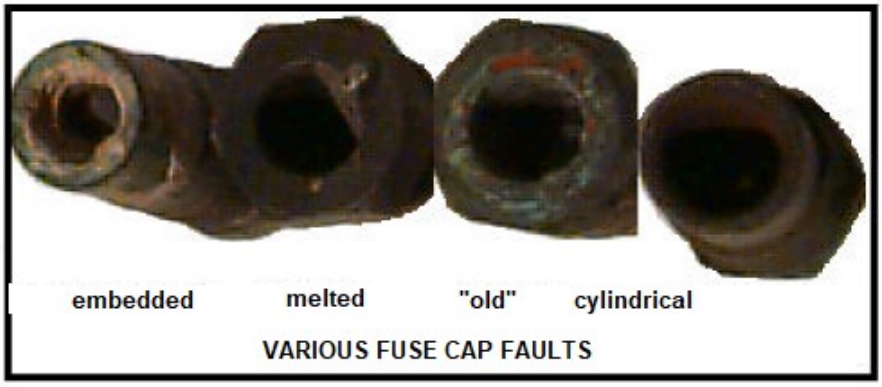
An additional hydrostatic test should be performed after replacing the fusible plug.

Otherwise, there is a risk of an accident, as a melted fusible plug indicates a loss of water level.

It is possible that a faulty fusible plug can melt over time (lack of taper, contaminated solder, insufficient cleaning during the melting process, such as when refilling the boiler).



DEFECTIVE FUSE CAPS



VARIOUS FUSE CAP FAULTS

The Feedwater Pump

Feedwater pumps perform the function of drawing feedwater into the pressurized boiler (replenishing the water that evaporates and maintaining the boiler's water level).

The feedwater in the pump is subjected to a process that increases its pressure above the boiler's internal pressure, overcoming the check valve, friction (pressure losses) in the pipes, and the internal pressure, and entering the boiler.

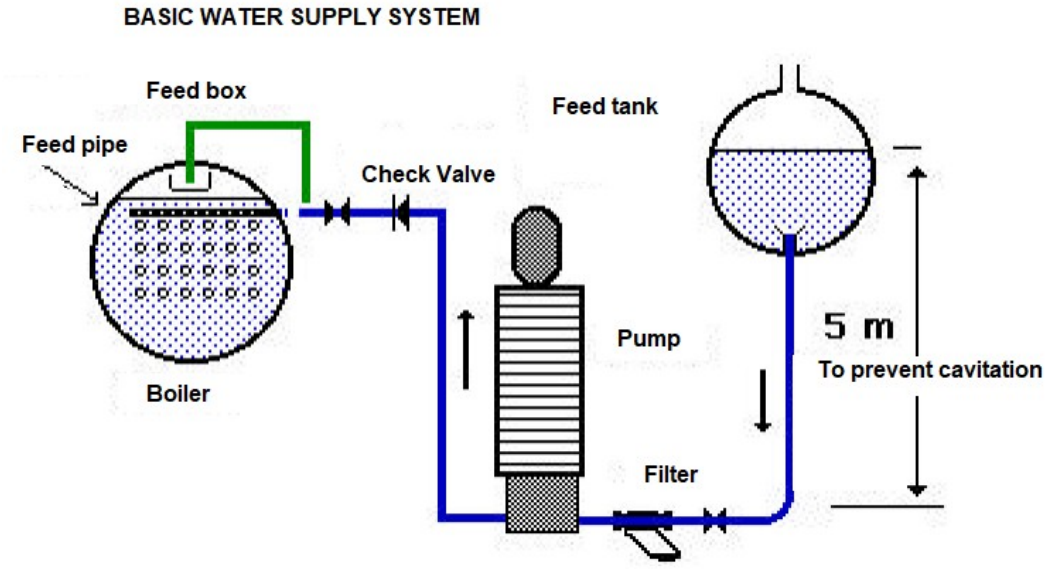
This check valve allows water to flow in only one direction, preventing the boiler from emptying when the pump is stopped or when the pressure is lower.

The pumps draw water from the "feed tank." This tank must be elevated at least 3 meters (ideally 5 meters) above the feed pump to ensure the pump is supplied with sufficient water pressure to prevent cavitation (the pump stops pumping, and steam bubbles or plugs form due to the suction vacuum approaching the boiling point; this problem worsens as the water temperature rises).

The feed water is heated because it is a mixture of condensate (hot to 100°C, 212°F in many cases) and cold makeup water.

If the feedwater is cold, it is advisable to heat it, if possible, to above 80°C (176°F) to avoid thermal shock with the water inside the boiler, which is at over 100°C (212°F) (depending on the operating pressure), and to expel as many dissolved gases as possible.

Furthermore, the boiler will also perform better when fed with hot water (since hot water requires less heat to reach the vaporization temperature plus the heat of vaporization, which together is the sum of the sensible and latent heats).



Water supply can be continuous: by regulating the boiler's inlet valve (opening or closing smoothly according to demand: modulating) manually or automatically.

Or it can be intermittent: by turning the feed pump on and off (manually or, generally, automatically: On-Off).

There are several types of feed pumps, not only because of how they "boost" the pressure, but also because of the type of energy used for their operation.

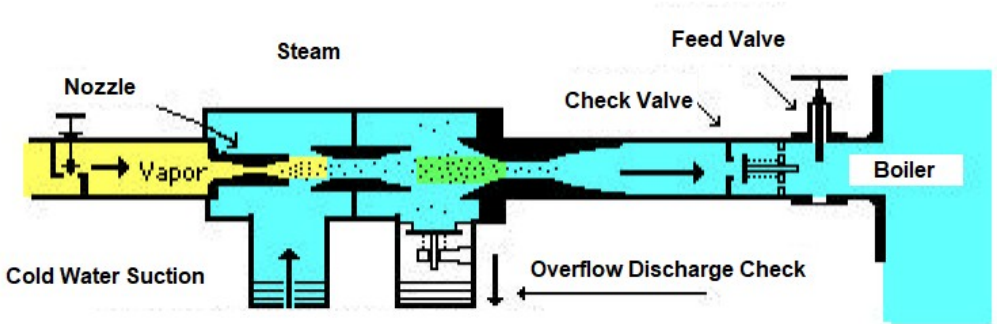
Therefore, we will find that not all types of feed pumps are suitable for continuous supply (which is ideal).

Feed types: via steam injector. It utilizes the energy of the steam from the boiler itself to propel the cold feedwater through a nozzle and diffuser.

As the steam condenses, its velocity increases, "pushing" the cold water and increasing its pressure, which overcomes the resistance created by the boiler pressure.

Its operation is continuous; regulating the flow of "live" steam to the injector somewhat regulates its capacity.

It is normally used as an auxiliary feed (especially in wood-fired boilers during power outages, to prevent the boiler from running low).



STEAM INJECTOR

Within the category of steam-driven pumps, we have several types:

Steam-driven pumps (steam turbines or steam reciprocating pumps: "donkeys"), which can be piston pumps (reciprocating) or centrifugal pumps (with sliding or "regenerative") driven by steam turbines.

By regulating the speed of the steam turbine, the water flow rate can be regulated, and in steam turbine pumps, it can be regulated with the pump's discharge valve (since they are sliding centrifugal pumps whose revolutions remain constant).

Electrically driven pumps are the most common. These include piston pumps (less common), centrifugal pumps of the "sliding" type, and "regenerative" (semi-positive displacement) type.

Piston pumps and some "regenerative" centrifugal pumps can only operate in an on-off mode.

Otherwise, their pressure would rise to levels that would stop the motor, or their energy consumption would be very high (unless a relief or regulated return system is installed).

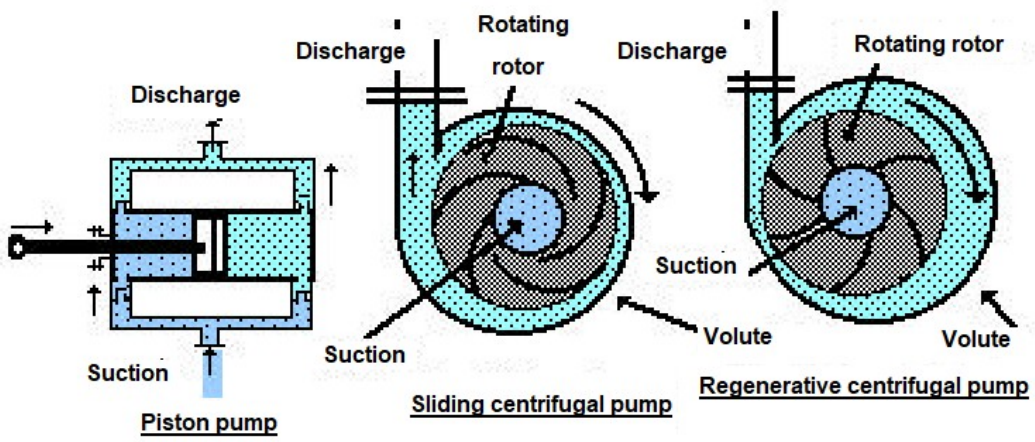
Sliding centrifugal pumps can operate in an on-off mode or by regulating the flow with the supply valve manually or automatically (since these pumps consume less energy when their discharge is closed, even if the pressure increases).

Centrifugal pumps operate based on centrifugal force (the force that tends to separate a body from its axis of rotation, for example: the bolas used by gauchos or David's sling).

Since each pump diameter and a specific rotational speed (RPM - revolutions per minute) corresponds to a specific pressure, several stages are used to increase the total pressure achieved.

The difference between a **"slip" pump and a "regenerative" pump** generally lies in the fact that a "slip" pump, by closing its discharge valve, reduces the energy consumption of the motor that drives it, while a "regenerative" pump increases energy consumption (similar to "positive displacement" pumps: gear pumps, for example, when a gear pump closes its discharge, the pressure increases to such high levels that it can rupture the discharge pipe or stop the motor).

The advantage of the regenerative pump in some cases is that it can achieve higher pressures with fewer stages, and in other cases, it has good suction characteristics (low risk of cavitation). However, in general, they are inefficient (consuming more energy than necessary).



In **centrifugal pumps**, the rotor (impeller) is made up of single (open rotor) or double (closed rotor) discs containing the vanes (curved ribs that propel the water as the impeller rotates).

This rotor is located inside a volute (pump casing or housing) that encloses the rotating water and, according to its shape, captures this rotating water flow and diverts it to the outlet pipe, thereby increasing its pressure (based on the energy it has taken from the impeller).

In all pumps, suction occurs because the water displaced by the discharge leaves a "free" space that tends to be filled by water from the suction pipe, "pushed" by atmospheric pressure (acting on the free surface of the tank or well).

Therefore, the suction of a cold water pump can be taken from a depth of approximately 7 meters (22.9 ft) (remember that atmospheric pressure is 10.033 meters (32.9 ft) of water column at sea level), but due to the vapor pressure of water (which varies with temperature) and friction losses in the pipes, this suction will be less than atmospheric pressure.

Pumps feeding hot water must be fed with positive pressure (above atmospheric pressure, i.e., the tank above the pump) and

not, as in the case of cold water, which can be "suctioned" from below the pump (pressure below atmospheric pressure, negative gauge pressure).

The diagram above (very basic) illustrates the difference between a **sliding centrifugal pump and a regenerative pump**. Note that in the latter, the forward-curved impeller vanes "push" the water towards the outlet, which causes the pressure to rise when the discharge is closed, increasing the energy required for pumping.

In the case of **sliding pumps**, the backward-curved vanes tend to "slide" when the discharge is closed, and since the water volume decreases (but not the pressure), energy consumption decreases (the pump can and should be started with the discharge closed to reduce the starting force).

Regarding centrifugal pumps, it's important to note that the pressure depends on the rotor's rotational speed (RPM - revolutions per minute) and its diameter, as well as the number of rotors in series (stages). The water volume of each pump depends on the discharge and suction pressures (pressure vs. volume curve).

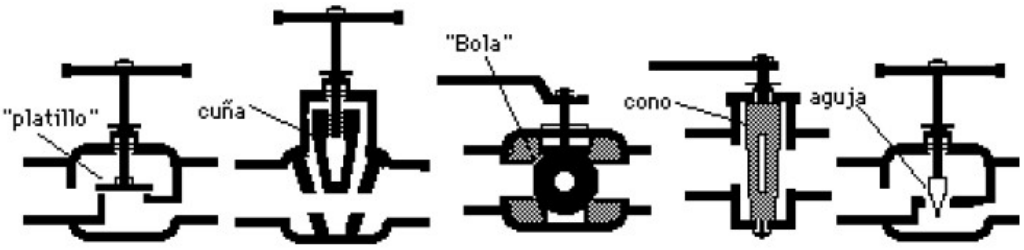
Furthermore, the impeller shaft must be sealed to prevent air from entering the suction line or water from leaking.

This sealing can be by "packing" (cords of material pressed in a "stuffing box": cotton, asbestos, Teflon, etc.) which must be adjusted periodically (or changed and which must lose a drop of water every so often for lubrication) or a mechanical seal (a ring of hard material: stainless steel, ceramic, etc. that rests against a soft and low friction material: carbon, graphite Teflon, etc.) with the great advantage of not needing maintenance (only changing in long periods) and which produce a very good seal (it is lubricated and cooled with the same water that it propels).

Valves

Valves are devices used to open or close the flow of a fluid (water, steam, etc.) in a pipe.

There are several types of valves: globe (disc), gate (wedge), ball, needle (a needle in an orifice), cone or cylindrical tap, piston, etc.

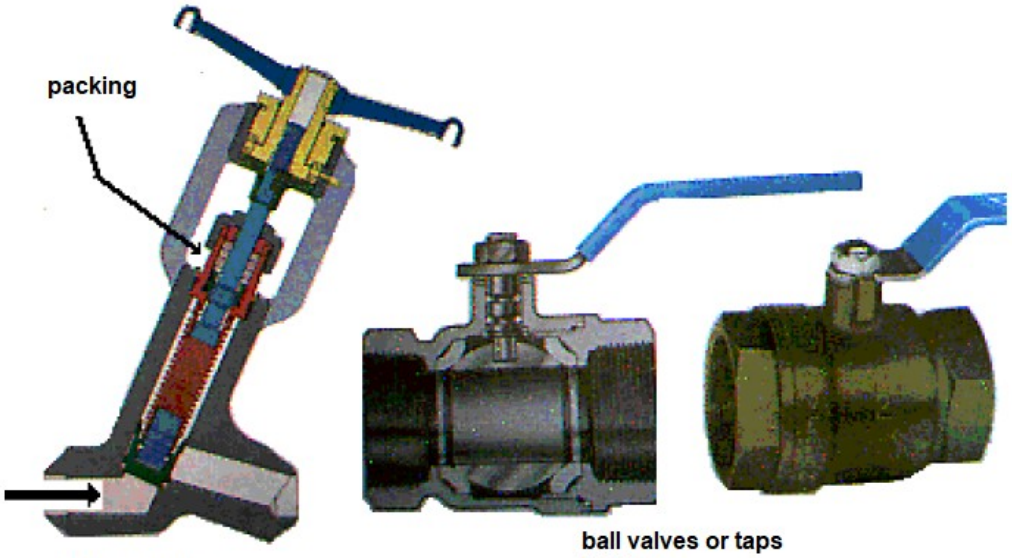


Globe Valve - Gate Valve - Ball Valve - Cone Valve - Needle Valve

They all have different qualities for their use: globe valves allow flow regulation without significant wear, gate and ball valves can be "full flow" (they do not restrict the flow - they should not be used for regulation), ball, piston, and tap valves can be quick-acting (quick opening and closing), and needle valves allow for very "fine" regulation.

Valve seats can be made of hard materials (steel, chromium-nickel steel, etc.) or soft materials (such as bronze, Teflon, Micarta, etc.) or a combination thereof. Some seats are replaceable (the soft ones) while others (the hard ones) can be ground.

Valve bodies are made of materials such as cast steel, alloy steels, gray cast iron, bronze, etc. (depending on their application). Therefore, there is a classification system that must be followed for their use (very important due to the pressure and temperature they must withstand).

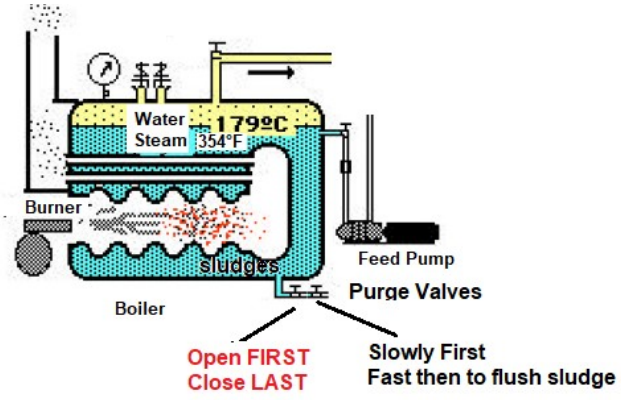


Valves for use in steam systems have a classification ("Series" 150, 300, 400, 600, etc.) that indicates the maximum pressure and temperature range for which they can be used.

A similar classification is used for pipes: the "Schedule" (20, 40, 80, etc.) indicates the wall thickness of the pipes.

Purge valves may be paired (this is advisable for safety): one slow-acting valve against the boiler and another fast-acting valve outside (both full-flow).

The operation should be performed by opening the valve against the boiler first and closing it last—opening the external valve slowly at first (to heat the pipe and then quickly to flush out the sludge).



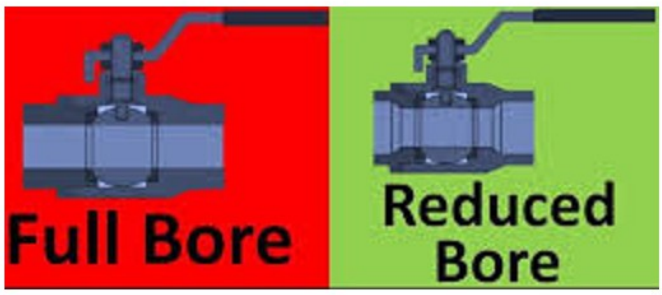
Valves must be operated with extreme care when under pressure from steam or hot water, and drain valves even more so (as they allow the boiler to be emptied in case of a rupture or failure to close).

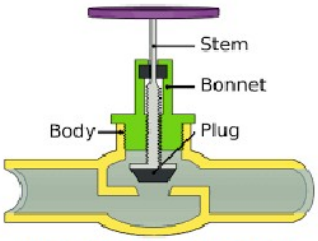
Steam valves should be opened gently, warming the pipes to prevent water hammer (the violent condensing of cold water and steam, which propels the water at high speeds against the pipes) and to account for pipe expansion (1 mm per meter per 100°C 212°F).

However, they must be fully open (to prevent "scoring" of the seat by steam, unless they are valves for regulating special seats: due to their shape and material, globe valves are more suitable for regulation).

A valve of one type should not be replaced with another type without first explaining the reason for the valve's selection.

A full-bore valve is understood to have been installed for complete opening and closing (with almost no pressure loss), and replacing it with a globe valve (with restricted flow) can generate a pressure loss that impairs operation, etc. (therefore, respect the "Series" classification).





Globe Valve (reduced bore)

The pipes are connected by fittings made of the same material and valves. These connections can be threaded, welded, or plated.

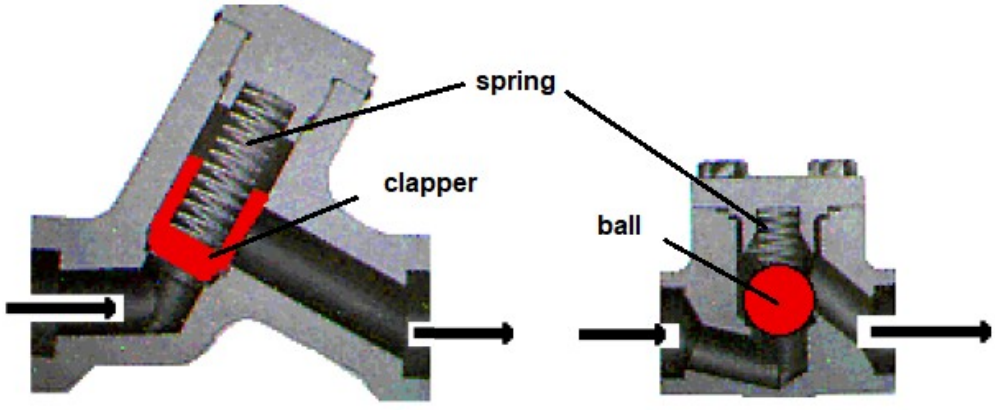
The threads must be sealed with a material appropriate for the temperature and pressure at which they operate (for example, in hot water: **Teflon tape (temperatura and steam clasified)** or paste, or a homemade paste such as red lead, graphite, and well-boiled linseed oil, or litharge and glycerin (for light fuels, some gases, etc.), or in cold water with hemp-based sealant, etc.).

The plates will be fitted with gaskets suitable for the pressure and temperature (Klinger, asbestos, specially shaped metals, graphite, etc.), using graphite flakes mixed with grease or oil (on both the faces and threads of the plate screws, which must be tightened evenly). See the chapter on gaskets and seals later.

Check valves

Are used to force flow in only one direction. They can be divided into: axial type (vertical, axial lift with guide) or swing type (or "flap" type, which can be 90° or 45°).

Swing valves have lower pressure losses, and the 45° type is ideal for steam and condensate flow (which require rapid opening and closing).

The comments regarding valve materials and their "Series" classification are also valid. Ball check valves perform well as check valves for boiler feedwater.

When more than one boiler is installed in parallel, check valves (suitable for steam) are placed at the steam outlet of each boiler (so as not to pressurize the lower-pressure boiler with the higher-pressure one—this is important not only for mechanical and safety reasons, but also for chemical reasons, as corrosion occurs).